Forschungsfabrik Mikroelektronik Deutschland

Green ICT @ FMD – Competence Center for Sustainable Information and Communication Technology

Environmental Relevance of ICT

The increasing energy consumption of ICT remains a key factor in the environmental impact

1.4% of global emissions result from the ICT use phase

4% of global electricity consumption originates from ICT

A semiconductor factory can consume **99 million liters of water a day**

The competence center "Green ICT @ FMD" supports companies in **improving the sustainability of their ICT products** and creates a solid database for **quantifying and minimizing the environmental impact of future ICT developments.**

Competence Center Green ICT @ FMD

Overview

Project partner

All 13 institutes of Forschungsfabrik Mikroelektronik Deutschland

Technology Hubs

- Sensor-Edge-Cloud
- Communication Networks
- Microelectronics Production

Complementary Activities

- Camps and Award
- Standardization
- Open Platform
- Green ICT Space
- Professional Development
- Green ICT Connect
- Accompanying Research

Competence Center Green ICT @ FMD

Our offers for different target groups

Industry

- Validation projects (direct involvement in our research results)
- Green ICT Space (start-up support)
- Green ICT Courses (continuing education and qualification program)
- Norms & Standards

Science

- Methodological support for research projects (accompanying research)
- Specialist articles, conference papers

Community

- Science communication on green ICT using interactive tools and training videos
- Press and public relations work (interviews, podcasts, etc.)

Students

- Green ICT Camp
- Green ICT Award for final theses
- Green ICT training videos

Pupils

- Green ICT games app for pupils
- Train-the-trainer program
- Target group-oriented science communication on green ICT

Politics

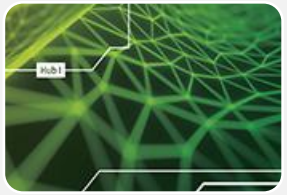
- Commissioned studies
- Norms & Standards

Comprehensive offers: **Green ICT Connect** (conference) and **Open Green ICT platform** (virtual 3D showroom)

Competence Center Green ICT @ FMD

3 Technology Hubs – Joint project goals

Hub 1: Sensor-Edge-Cloud

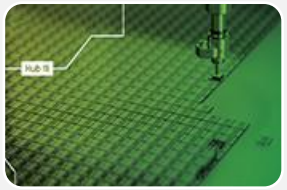


- Embedded green AI
- Self-sufficient IoT-sensor nodes
- Multi-sensor platform
- Green edge computing and edge cloud systems

Hub 2: Energy-saving Communication Networks

- 5G testbed
- X-haul wireless network
- X-haul optical network

Hub 3: Resource-optimized Microelectronics Production



- Processing
- Cleanroom infrastructure
- Energy optimization
- Back-end technologies
- Material reduction and replacement

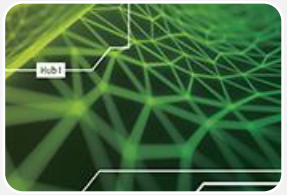
Project goals

- Pooling **FMD's expertise in the field of ICT** within the Competence Center Green ICT @ FMD
- Establishing a **central contact point** for industrial user groups, to provide answers to their questions
  - Resource-saving microelectronics/MEMS fabrication processes
  - Energy-optimized sensor edge cloud systems and communication networks
  - Life cycle and environmental assessment of existing products and processes
  - Recent and upcoming regulations and the establishment of standards for ICT products and processes
- **Training and encouraging** students, young professionals and employees on issues of relevance to Green ICT
- **Developing a community** of relevant stakeholders in the field of green ICT

Competence Center Green ICT @ FMD

3 Technology Hubs – 2 Possibilities for cooperation

Hub 1: Sensor-Edge-Cloud



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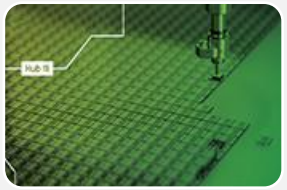

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Industrial user groups

- Identify the most important technological topics together with our experts
- Participate in the latest findings, data and process optimizations
- Network with other stakeholders in your line of business
- Benefit from our expertise in energy and resource optimization of ICT products and processes

Validation projects

- Benefit from our test environments and cleanroom infrastructure
- Adapt modern “green” knowledge to your ICT product or process
  - Learn about the carbon footprint of your ICT product or manufacturing process
  - Reduce costs with 100% coverage of the utilized FMD services

Your Contact at the FMD Business Office

Dr. Manuel Thesen
Project Manager
+49 171 8491 370
manuel.thesen@mikroelektronik.fraunhofer.de

Dr. Hans Walter
Standardization and Education
+49 173 5840 124
hans.walter@mikroelektronik.fraunhofer.de

Lotta Adu
Environmental Assessment
+49 151 7050 7842
lotta.adu@mikroelektronik.fraunhofer.de

Dr. Daniela Hübler
Green ICT Space
+49 151 7261 9479
daniela.huebler@mikroelektronik.fraunhofer.de

Tuğana Ceren Aslan
Environmental Assessment
+49 151 2136 0503
tugana.aslan@mikroelektronik.fraunhofer.de

Nadiia Telenchuk
Eventmanagement
+49 151 5142 6908
nadiia.telenchuk@mikroelektronik.fraunhofer.de

Competence Center Green ICT @ FMD

Your Contact for the Green ICT Hubs

Hub 1: Sensor-Edge-Cloud Systems	**Josef Bernhard,** Hub Management **josef.bernhard@iis.fraunhofer.de**	**Sylvie Couronné,** Deputy Hub Management sylvie.couronne@iis.fraunhofer.de
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Hub 3: Microelectronics Production	**Jörg Amelung,** Hub Management joerg.amelung@ipms.fraunhofer.de	**Marco Kircher,** Deputy Hub Management marco.kircher@ipms.fraunhofer.de
Life Cycle Assessment	**Dr. phil. Lutz Stobbe** lutz.stobbe@izm.fraunhofer.de	**Dr. Nils F. Nissen** nils.nissen@izm.fraunhofer.de

A News Snack for in Between?

More information on the Green ICT @ FMD competence center

Newsletter subscription

Project website

3D-showroom

Gefördert durch:

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für Forschung, Technologie
und Raumfahrt

Forschungsfabrik Mikroelektronik Deutschland

Green ICT @ FMD – Competence Center for Sustainable Information and Communication Technology

Our Offer for the Industry and SME

Hub 1: Sensor-Edge-Cloud Systems

Hub 2: Energy-saving Communication Infrastructure

Hub 3: Resource-optimized Microelectronics Production

Fraunhofer IZM: Life cycle assessment

Green ICT Space

Forschungsfabrik Mikroelektronik Deutschland
A cooperation of Fraunhofer MIKROELEKTRONIK

Competence Center Green ICT @ FMD

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User Groups & Validation projects

Opportunities by participating in user groups

- Participation in the professional and technical alignment of our hubs
- Joint definition of potential issues

Added Value

- Access to customized data collection for specific Green ICT issues
- Feedback on the Hubs' approach and on any requirements regarding further support to be provided by the Competence Center
- Opportunity to participate in specific implementation projects
- Direct participation in the Green ICT network and thus access to many players in the industry

Opportunities by participating in validation projects

- Use of test laboratories including expertise and equipment
- Evaluated test balloons can be used to compare your own market potential
- Interdisciplinary expertise (at technical implementation level and for life cycle assessment)
- Fast and unbureaucratic access to results
- Precise assistance and result identification based on pre-evaluated topics
- Free participation through 100% funding of the services provided

More about the user groups and validation projects here

Validation Projects

Sustainability booster for your product

Other companies
Hub thematic relevance

User Groups
Impulse and input of industrial requirements

Service offerings

- Hub 1
- Hub 2
- Hub 3

Validation Project

1. Project proposition / company
Specific proposition based on hub topics
Not part of the hubs, but can be addressed

2. Feasibility studies / hubs
Feasibility (finances, technology, timing)

3. Selection process / hub expert board
Criteria e.g. CO_2 or resource savings potential

Hubs

Options for analysis & results for validation projects

- Life cycle assessment
- Setting the baseline
- Environmental potential
- Key performance indicator KPI (e.g. energy efficiency)
- Material substitution
- Carbon footprint reduction
- …

Competence Center Green ICT @ FMD

Validation projects exemplified by Hub 1: Sensor-Edge-Cloud

Procedure after project approval by the management committee

Project definition
- Technical input from industry partner
- Joint definition of the project goal
- Clarification of the general conditions (schedule, contributions from industry partners, information and results definition for dissemination)

Project implementation
- Analysis implementation
- Frequent coordination with industry partner

Project completion
- Documentation of results in a white paper
- Dissemination of (partial) results after coordination with the industry partner

Two validation projects launched with industry

- Use Case **Metering** → TF2 **Self-Sufficient IoT Sensor Nodes** as drivers

Impact of different wireless communication and energy supply systems on carbon footprint of a metering solution

- Use Case **Condition Monitoring** → TF1 **Embedded Green AI** as drivers

Life cycle assessment comparison of different embedded AI hardware modules for condition monitoring in machine tools

Two further validation projects are currently in the application phase (mainly TF3 **Green Multisensor Platform**)

Project duration 3-6 months depending on coordination with industry partner

Service Portfolio Hub 1: Sensor-Edge-Cloud

Ecological design of products and processes – what we can offer

Technology field	Technological offers	Life cycle assessment offers Environmental potential analysis
Embedded Green AI	Database with key data for the life cycle assessment of AI hardware	Comparison of energy consumption of the customer-specific AI solution on different hardware platforms
	Automated energy evaluation of hardware (microcontroller, application processor, neuromorphic)	Develop and realise optimisation potential at hardware and **software** level
	Software combinations for AI models	
Self-Sufficient IoT-sensor nodes	Analysis and optimisation of energy consumption and selection of components for the embedded sensor solution	Characterisation of energy efficiency
	Concepts for energy supply (e.g. with energy harvesters)	Carbon footprint assessment (material/production, in-use)
	Implementation of the IoT sensor node	Development of optimization methods

Service Portfolio Hub 1: Sensor-Edge-Cloud

Ecological design of products and processes – what we can offer

Technology field	Technological offers	Life cycle assessment offers Environmental potential analysis
Green Multisensor Platforms	Metrological evaluation of sensor components and systems	Carbon footprint assessment of sensor components and sensor systems: (technology selection and benchmarking)
	Consulting on optimizing architecture, operational management and component choice	Overall system analysis from data processing and data transmission to architecture
Green Edge Computing & Edge Cloud Systems	Energy-efficient containers and virtualization on distributed embedded systems	Energy savings in partial load scenarios through intelligent dynamic software distribution and targeted switch-off
	Support with system integration/adaptation to industry requirements	
	PoL circuit design	Integrated current sensor nodes as a measuring instrument with evaluation in the Edge Cloud using AI
	AI to optimize the edge cloud system solution	

Service Portfolio Hub 2: Communication Networks

Ecological design of products and processes – what we can offer

Range of topics	Technological offers	Life cycle assessment offers Environmental potential analysis
5G Testbed	Development and testing of algorithms/apps for network optimization with regard to energy consumption Conformity, interoperability and performance tests of O-RAN radio units with simultaneous recording of power draw	Not planned
X-haul wireless	Consulting: digitalization, energy-efficient circuits/ modules/ frontends Measuring stations Components: Digital TRx, MMIC development, modules, subsystems, system architecture, antennas and MIMO up to 300 GHz Outdoor test fields: D-band, H-band and 60 GHz links	Balancing InP-HBT and GaN processes Digitalization Results D-Band and H-Band links
X-haul optical	Consulting: Characterization of transmission systems, subsystems or optical components with regard to energy consumption - in close relation to measuring stations Test stations: Optical Access Network, Optical Wide Area Network, 110 GHz Lightwave Component Analyzer, TSN Testbed	Data analysis on the energy consumption of components, subsystems and installations as part of the established measuring stations

Service Portfolio Hub 3: Microelectronics Production

Ecological design of products and processes – what we can offer

Range of topics	Technological offers	Life cycle assessment offers Environmental potential analysis
Processing	Replacement of traditional batch furnace processes by rapid thermal processing in the field of high-quality oxides (e.g. gate oxidation) for the production of complex technologies for small and medium quantities	Evaluation of material and energy consumption for technology modules
	Establishing IN/OUT material and energy flows of a coater and developer in an industrial environment	Process-based carbon footprint calculation and optimization
Cleanroom & infrastructure	Harmful gases, investigation of PECVD cleaning processes. Available cleaning gases: PFCs, SF_6, NF_3, FAN	Consulting on exhaust gas cleaning only with scrubber operation without fuel gas for FAN-based cleaning
		Use of an RPS-based cleaning system for PECVD with NF_3 and FAN gases using a microwave-based plasma source
Energy management	Balancing of processes that are linked to energy quantities, including optimisation	Life cycle assessment of oxidation processes
	Consulting on energy efficiency when using machines and systems. With mobile energy loggers, the electrical parameters can be recorded with time resolution and correlated directly with running processes	Depending on the initial situation, tool-specific energy savings of up to 25 % can be achieved. Measurements allow life cycle assessment of single processes

Service Portfolio Hub 3: Microelectronics Production

Ecological design of products and processes – what we can offer

Range of topics	Technological offers	Life cycle assessment offers Environmental potential analysis
Material substitution	EKC265 Substitution for cleaning Si wafers after the Bosch Si etching process	Use of solvents or solvent mixtures that are not carcinogenic and not very harmful to aquatic organisms
	Introduction of more environmentally friendly alternatives than EKC265 for cleaning	EKC265 alternatives: Fluorides, amines, hydroxylamine and pyrocatechol-free, low process temperature, without rinsing with isopropanol
	Process optimization with slurries from less critical sources or materials, advice on recycling tools, characterization on test structures	Replacement of Ce- by SiO_2-containing slurries; reduction of water consumption in the post-process, recycling and re-use of slurries, determination of consumption and carbon equivalents
	Consulting on FAN gas installation, development and optimization of the plasma cleaning concept	Replacement of the cleaning gases C_2F_6 and NF_3 with FAN
	Process parameters for the production of InGaAs/InAlAs/InP heterostructures on silicon substrates	Replacement of He as precursor gas by Ar
	Alternative materials to NMP: testing possibilities through extensive knowledge using different characterisations	Arsenic reduction of 99.99 % in electronic high-frequency circuits
		Process evaluation without NMP

Evaluation of material and energy consumption for entire technology processes in terms of consumption vs. expenditure

Service Portfolio Fraunhofer IZM

Your technological interface with us and our offers for ecological improvements

Range of topics	Technological offers	Life cycle assessment offers Environmental potential analysis
Electronics production and components	Assessment of life cycle inventory data: Non-destructive by means of X-ray and CT, destructive by means of high-resolution grinding techniques (e.g. FIB) Reliability tests (e.g. thermal cycling, vibration, humidity, shear tests, tumble tests, drop tests, tensile tests and combinations of several tests; surface density determination)	Consulting and preparation of life cycle inventory models Methodological consulting on ISO 14040/44 and definition of specific requirements for special applications Third-party review for life cycle assessments Plausibility check for life cycle assessment data sets (especially for electronic component production and printed circuit boards) Consulting on and implementation of eco-design and recycling concepts Consulting on environmental legislation and requirements in the field of electronics (not legally binding) (e.g. substance bans, DPP, Ecodesign Directive, …)

Green ICT Space for startups und SMEs

Benefit from our infrastructure for your product development

Green ICT Space

- **Accompanies** and **promotes product ideas** to develop them in an **environmentally friendly** and **resource-saving** manner
- **Offers** the necessary **support** for the **technological challenges** in the area of **Green ICT**
- **Bringing together** complementary **competencies** from multiple **FMD-**Institutes
- **Use** of **clean rooms** and **over 2200 machines** and **equipment** of the Competence Center **Green ICT @ FMD**

Our Services

- Demonstrators
- Prototypes
- Pilot Manufacturing
- Life Cycle Assessment

Incentive

- Preparation of a life cycle assessment, a potential analysis or a calculation of the CO_2 footprint of your ICT product or process
- Support in identifying, collecting and analyzing the required data

Conference Green ICT Connect

Overview

- Goal: Networking of science, industry and politics, students are welcome
- Program: 2 days of expert presentations, panel talks, industry pitches, networking/matchmaking, networking evening
- Also: Hub lounges, accompanying exhibition, breakfast for women scientists, (Green ICT award)
- Free participation, language: German
- On site and via livestream
- Up to 150 participants on site

Key areas of focus: Research and industrial activities in 3 technological fields: Sensor-Edge-Cloud Systems / Energy-saving Communication Infrastructures / Resource-optimized Electronics Production

More information here

Contact: Nadiia Telenchuk

Event review 2024

Green ICT Connect 2025

October 15-16

Change Hub Berlin

Your Contact at the FMD Business Office

Dr. Manuel Thesen
Project Manager
+49 171 8491 370
manuel.thesen@mikroelektronik.fraunhofer.de

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Standardization and Education
+49 173 5840 124
hans.walter@mikroelektronik.fraunhofer.de

Lotta Adu
Environmental Assessment
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lotta.adu@mikroelektronik.fraunhofer.de

Dr. Daniela Hübler
Green ICT Space
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daniela.huebler@mikroelektronik.fraunhofer.de

Tuğana Ceren Aslan
Environmental Assessment
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tugana.aslan@mikroelektronik.fraunhofer.de

Nadiia Telenchuk
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nadiia.telenchuk@mikroelektronik.fraunhofer.de

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3D-showroom

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Our Offer for Students

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October 15-16

Change Hub Berlin

Summer and Winter School for Students – Green ICT Camp

Overview

- Students in the 4th semester or higher
- 50 participants
- Monday to Friday, all-day program
- application: online
- **Free of charge**

More information here

Contact: Nadiia Telenchuk

Imparting basic knowledge, specialized know-how and **soft skills** by:

- Discussion rounds
- Workshops / group work
- Side-Events incl. gala evening
- Trainings (composing scientific articles, presentation skills etc.)
- Company excursions incl. Best Practice
- Competition with an award ceremony

Camp 1: Communication Networks	September 2-6, 2024
Camp 2: Sensor-Edge-Cloud Systems	March 24-28, 2025
Camp 3: Microelectronics Production	September 1-5, 2025

Green ICT Camp: Why You Should Take Part

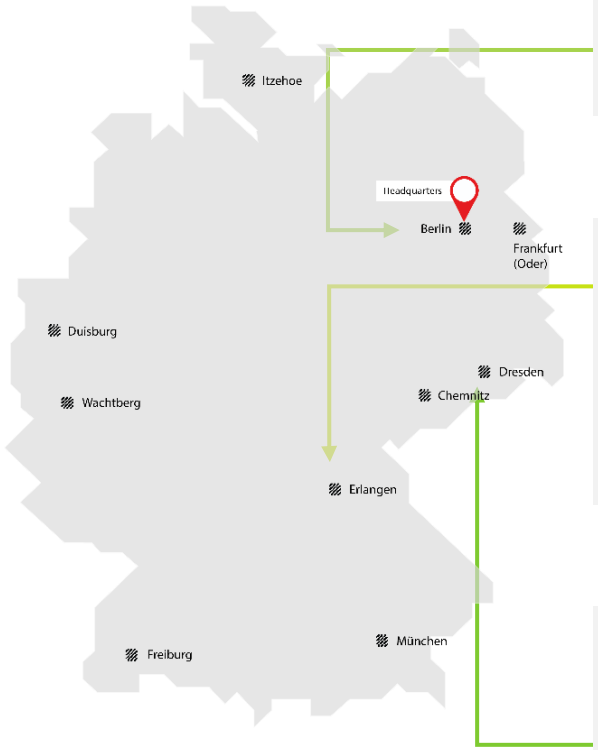
Our 5 reasons

Students

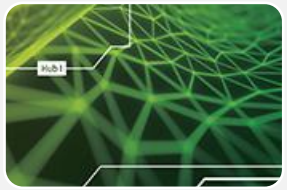
- learn from **experienced scientists** what is essential for green ICT
- receive the **basics and in-depth information into life cycle assessment** of ICT-relevant processes and technologies
- gain a **deeper insight into research and industry** through excursions and keynote speeches
- get **specific tips** for planning their career in this field
- have the opportunity to **develop their networks**

Summer and Winter School for Students – Green ICT Camp

Topics and dates



Camp 1: Communication Networks (Hub 2)



- 5G testbed
- X-haul wireless network
- X-haul optical network

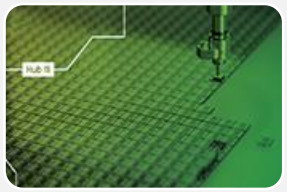
Summer school 24: Berlin
September 2-6, 2024
together with FBH

Camp 2: Sensor-Edge-Cloud Systems (Hub 1)

- Embedded green AI
- Self-sufficient IoT-sensor nodes
- Multi-sensor platform
- Green edge computing and edge cloud systems

Winter school 24/25: Nürnberg/Erlangen
March 24-28, 2025
together with Fraunhofer IIS

Camp 3: Microelectronics Production (Hub 3)



- Processing
- Cleanroom infrastructure
- Energy optimization
- Back-end technologies
- Material reduction and replacement

Summer school 25: Dresden
September 1-5, 2025
together with Fraunhofer IPMS

The Green ICT Award for Students

Overview

- Students and young professionals
- Bachelor's and Master's theses from German universities and colleges, must not be older than two years
- Apply online with a long abstract on the Green ICT homepage
- Courses of study:
  - Microsystems engineering, micro- and nanotechnology,
  - electrical engineering, embedded systems (design), physics, and the like
  - computer engineering, information technology, etc.
  - environmental economics, energy, and environmental engineering; environmental and resource management, etc.
  - related courses und Cross-cutting topics

More information here

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Review of the 2024 award ceremony

Award ceremony 2025

October 15, Berlin

as part of the Green ICT Connect

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Dr. Manuel Thesen
Project Manager
+49 171 8491 370
manuel.thesen@mikroelektronik.fraunhofer.de

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+49 173 5840 124
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Environmental Assessment
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Eventmanagement
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