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Frederik Banis

System Optimization and Automation *PhD, Engineer, Researcher, Lecturer*

Energy systems engineer with a PhD specializing in control, optimization, and data-driven modeling for microgrids, smart buildings, and district energy systems. Five years of experience in R&D project management, applied engineering, teaching, and multinational collaboration at ETH (Zurich) and DTU (Copenhagen). Strong ability to translate advanced modeling and control methods into real-world engineering solutions that improve energy performance, reduce operational costs, and enable digital transformation.

Core Skills

Energy & Built Environment

- Microgrid modeling, flexibility, DER integration, district energy & multi-energy hubs
- HVAC & building energy systems
- Carbon reduction & energy performance optimization

Control & Optimization

- Model Predictive Control (MPC), LQR, observers, operational & economic optimization (nonlinear/convex/QP)
- System identification & dynamical modeling, physics-informed ML for energy systems

Data & Digital Engineering

- Python, MATLAB, Modelica, Pyomo, Gurobi
- Forecasting, anomaly detection, uncertainty analysis
- Digital twin algorithm design & simulation pipelines, data acquisition, hardware/software-in-the-loop

Consulting & Project Delivery

- Stakeholder communication, technical reporting & feasibility analysis
- Cross-disciplinary coordination
- Teaching, workshops, mentorship

Experience

(recent)

6-month sabbatical, continuing education and consultancy work, Asia.

2025–

- 6-month independent travel across Asia (China, Thailand, Japan, South Korea)
- Continuing education, including Mandarin, Machine Learning, Deep Learning
- Technical project consultancy for a Swiss company in the area of Large Language Models (LLMs) and automation
- Journal reviewer

Scientific officer and data manager, ETH*, Zurich, Switzerland.

2020–2024

Multiple roles in a dynamic environment in automation & energy engineering:

- Scientific Officer: Scientific and operational management for NCCR Automation, including leading research institutions in Switzerland such as ETH Zurich and EPF Lausanne. Coordinated labs, equipment, measurement setups and student projects
- Data Manager: Research data management for the Swiss National Centre for Competence in Research for Automation (NCCR Automation), ETH Zurich Data Steward. Developed data pipelines, tools and reproducible workflows

*ETH Zurich ranked 7th (QS World University Ranking 2026)

Education

Postdoctoral researcher, ETH*, Zurich.

2020–2024

Applied Energy & Automation Engineering

- Principal teacher of the “Quad-Rotors” course (also [here](#)) teaching students how to automate drones. Principal responsible for the “Control Experiments Lab” at IfA. Supervision of student theses.
- Project management for the PSL photovoltaic laboratory: Management of the PV plant and associated laboratory deployment work, creation of teaching material for undergraduate courses as well as advanced courses in continuing education.
- Research with Empa on nonlinear system identification at the NEST building
- Reviewer for IJCAS

*ETH Zurich ranked 7th (QS World University Ranking 2026)

PhD Researcher in Energy Systems, DTU* Compute, Copenhagen.

2016–2020

Efficient Operation of Energy Grids (Microgrids, MPC)

- Doctoral Thesis [Efficient Operation of Energy Grids](#)[[banis_efficient_2020](#)]: Developed MPC and optimization frameworks for microgrids, frequency control, and price-based flexibility. Built forecasting, model-fitting, and scenario analysis tools used for energy system design studies.
Supervisors: Profs. Dr. N. K. Poulsen, Dr. D. Guericke, Dr. H. Madsen
- Projects: uGrip funded via the ERA-NET SmartGrids Plus program; CITIES
- Teaching assistance: Stochastic Adaptive Control (SAC), Dynamic Programming (discontinued), special course “Microgrids”, student theses and projects
- Courses taken: Static and dynamic Optimization, Model Predictive Control, Constrained Optimization, Teaching and Learning, EECI Model Predictive Control

*DTU Copenhagen ranked 107th (QS World University Ranking 2026)

M.Sc., University of Applied Sciences, Stuttgart.

2013–2016

Sustainable Energy Competence. Energy systems engineering, mathematical modeling, scientific work theory, team- and project management. Thesis *Evaluation of an ice rink energy management concept comprising CO₂ refrigeration* [[banis_evaluation_2015](#)] grade 1.3 (equiv. A) | KTH* Stockholm & EKA

*KTH Stockholm ranked 78th (QS World University Ranking 2026)

B.Eng., University of Applied Sciences, Weihenstephan-Triesdorf.

2009–2013

Renewable Energy Technology. Engineering key competences, including thermodynamics, fluid dynamics, mathematics, physics, chemistry and energy efficiency. Leader of a sports group. Thesis “Energetic examination of a CO₂ regulated ventilation system”[[banis_energetische_2013](#)] grade 1.0 (equiv. A)

Experience

(pre-PhD)

Coding, EMPA, Dübendorf, Switzerland.

2016

Google Summer of Code: Energy System Modeling Developer.

Developed a modular energy hub simulation framework (Pyomo), enabling multi-energy system optimization[[google_summer_of_code_google_2016](#)] for researchers. Project proposed to the list of exemplary projects of the 2016' Google Summer of Code

Research assistant, IAR and IFK, Stuttgart, Germany.

2014

Held two research assistant positions at the Institute of Applied Research (IAR) and Institute of Combustion Science (IFK) of the University of Stuttgart

- IAR: Programming and optimization of a station for the feed-in of solar heat at the institute. The work included the use of the real-time embedded industrial controller CompactRIO by National Instruments, and LabVIEW. Provided several feedback control systems for an optimized operation of the station [[banis_programmierung_2014](#)]
- IFK: Development of a LabVIEW program for the use of exhaust sensors. Established an automated operation of the measurement system. Filtering of messages on a CAN-Bus. Assembly of the system in a gas-powered combined heat and power unit [[banis_untersuchungen_2014](#)]

International exchange, IAESTE, Quito, Ecuador.

2013

Student exchange program via IAESTE (International Association for the Exchange of Students for technical Experience). Creation of 3D models and vector graphics, translation work

Intern and part-time job, blumartin, Munich, Germany.

2011-2013

Project management, assistance of the corporate management. Technical service and support. Organization of trade show participation, including product and business presentations, product FAQ, product picture procurement. Bachelor thesis (1.0, equiv. A)[[banis_energetische_2013](#)]

Skill Matrix

	Level	Skill	Years	Comment
Languages	■■■■■	English	10+	Daily use both professionally and in private
	■■■■■	German		Mother tongue
	■ ■ ■ ■ ■	Mandarin		2 years of regular study and exposure, currently at HSK2 level & expanding through self-study
	■ ■ ■ ■ ■	French, Spanish, Russian		2 years of training in French in high school
Data Science Tools	■■■■■	Python	10+	Main language throughout academic career
	■ ■ ■ ■ ■	MATLAB, R	8 (2)	Occasional use
	■■■ ■ ■	Machine & Deep Learning	5+	Strongly related work during PhD, currently expanding my knowledge
Data Engineering	■■■■■	Git, GitLab, GitHub, Bash, Data Pipelines	10+	Regular use on a daily basis
Modeling Techniques	■■■■■	Predictive Modeling, Control Systems, Optimization	9+	Intensive use throughout academic career, including tools such as CasADI or Gekko
Collab. & Methods	■■■■■	Agile, Project Management, Cross-functional Leadership	5+	Focus during employment at ETH Zurich

Education Highlights

PhD:
Control & Optimization Model Predictive Control; Stochastic Adaptive Control; EECI International Graduate School on Control Paris: Model Predictive Control; Constrained Optimization; Static and Dynamic Optimization; Dynamic Programming; “Modern Challenges in Power System Operation and Electricity Market: An Optimization Perspective”
Other DTU Compute PhD Seminar; Teaching and Learning

Continuing Education:
AI Google AI Essentials; IBM Introduction to Artificial Intelligence (AI); IBM Introduction to Neural Networks and PyTorch; IBM Deep Learning with PyTorch; IBM Introduction to Deep Learning & Neural Networks with Keras; IBM Generative AI: Introduction and Applications; IBM Developing AI Applications with Python and Flask; IBM Generative AI: Prompt Engineering Basics; Vanderbilt University Prompt Engineering for ChatGPT; IBM Fundamentals of AI Agents Using RAG and LangChain; IBM Python for Data Science, AI & Development; IBM AI Capstone Project with Deep Learning
Management Operations Research (1): Models and Applications, Operations Research (2): Optimization Algorithms Operations Research (3): Theory
Control CasADi Hands On Optimal Control
Other IBM What is Data Science?; IBM Tools for Data Science
OpenClaw (agentic AI) setups

Project Highlights

Modular Energy Hub Modeling Framework, Empa. **Google Summer of Code**

- Developed a modular, object-oriented energy system modeling framework with support for hierarchical composition and optimization.
- Applied AI/ML-adjacent techniques including deterministic optimization modeling (Pyomo) and time-series data integration (Pandas).
- Facilitated scalable energy network representations with extensibility toward AI-driven decision-making and ML-based forecasting.
- Utilized tools such as **Python**, **Pyomo**, **Pandas**, and **GraphViz** for modeling and visualization.

Prosumer Response Estimation Using SINDyc and MCMC, DTU.

Applied in the context of smart energy systems to estimate prosumer response dynamics

- Developed a data-driven modeling framework combining **SINDyc (Sparse Identification of Nonlinear Dynamics with Control)** and **Bayesian inference (MCMC)**.
- Applied **machine learning** techniques to identify sparse nonlinear dynamic models from observed data under uncertainty.
- Implemented probabilistic modeling using **Stan** and the **No-U-Turn Sampler (NUTS)** to efficiently perform posterior inference.
- Quantified uncertainty in model parameters, improving robustness and enabling application in **stochastic model predictive control**.
- Gained hands-on experience in **ML for dynamical systems**, **Bayesian statistics**, and real-world system modeling constraints.

Project Highlight: Smart Microgrid Control with MPC and Kalman Filtering, DTU.

- Designed and implemented a **Kalman filter-based disturbance observer**, applying Bayesian estimation techniques for real-time state and disturbance tracking. Applied Kalman filtering techniques for dynamic state estimation in noisy environments, analogous to time-series forecasting and anomaly detection in AI.
- Developed model-based predictive controllers (MPC) to **optimize dynamic decision-making under uncertainty**, conceptually aligned with reinforcement learning. Developed and implemented Model Predictive Control (MPC) algorithms for real-time optimization of microgrid operations using forecast and system state data.
- Applied state-space modeling and **system identification** to build simplified yet physically realistic models for control and forecasting.
- Validated controller performance through **data-driven simulations** and sensitivity analysis, akin to ML model evaluation and stress-testing.
- Integrated stochastic estimation and optimization within constrained control frameworks
- Integrated heterogeneous data sources through the MOSAIK co-simulation platform, enabling **real-time coordination across hierarchical control layers**.
- Gained practical experience in AI-driven control systems, mathematical modeling, and real-time systems integration, with strong relevance to AI applications in energy, robotics, and industrial automation.

Project Highlight: Applied Machine Learning & Data Science in Energy Systems (Master's Thesis), KTH*.

- Developed **Python-based data pipelines** for high-frequency **sensor data** preprocessing, including **cleaning**, **resampling**, and **feature engineering**.
- Applied **statistical modeling**, **regression analysis**, and **clustering techniques** to evaluate performance and detect system patterns.
- Utilized **kernel density estimation (KDE)**, **quantile-based correlations**, and **custom performance metrics** to uncover optimization opportunities in a real-world **CO₂ refrigeration system**.
- Modeled and compared **control strategies** and **system configurations** using **predictive analysis** and scenario-based simulation methods.

Project Highlight: Energetic Analysis of a CO₂-Controlled Ventilation System (Bachelor's Thesis, HSWT).

- Designed and implemented a **rule-based control algorithm** for dynamic **CO₂-driven ventilation**, integrating **sensor data** with **Excel-linked control logic** in *TRNSYS*.
- Simulated and analyzed **time-series energy data** under varying **occupancy schedules** and **climatic conditions**, using **data-driven modeling** techniques.
- Performed **data collection**, **preprocessing**, and **regression analysis** to estimate thermal system parameters (*kA-values*, power consumption), applying statistical curve fitting.
- Applied core concepts of **automation**, **control systems**, and **building simulation**, building early expertise in **cyber-physical systems** and **data-centric optimization**.

Teaching

Quad-rotor P&S, ETH Zurich, Zurich, Switzerland.

2023-2024

- Content: A course teaching students how to control drones (quad-rotors) autonomously, covering mathematical/physical modeling, control and estimation fundamentals, controller tuning, coding, as well as extensive in-lab testing flying session. The course finishes with a custom project executed by the students
- Role: Lecturer and lab manager
- Course website

Control Experiments Lab, *ETH Zurich*, Zurich, Switzerland. 2023-2024

- Content: A set of control experiments, providing students with the opportunity to apply their theoretical insights to practice. Experiments range from simple experiments such as the control of the "flight level" of a ball in an airstream over helicopter control to the more involved quad-tank system
- Role: Lab manager and lecturer

CAS ETH in Applied Technology in Energy, *ETH Zurich*, Zurich, Switzerland. 2021

- Content: A course covering topics all the way from energy system and power system fundamentals to current innovation, such as modern control approach for these systems
- Role: Teaching assistant
- [Course website](#)

Special course Microgrid Optimization, *DTU*, Copenhagen, Denmark. 2019

- Content: A special course for a single student on microgrid optimization.
- Role: Lecturer

Dynamic Programming, *DTU*, Copenhagen, Denmark. 2018

- Content: "Optimization over function spaces; calculus of variations. Pontryagin's maximum principle; Hamiltonian formalism. Dynamic programming on graphs. Markov Decision Problems. The Hamilton-Jacobi-Bellman equation for optimal control. Dynamic games; mean-field games. Numerical methods for optimal control" ([link](#))
- Role: Teaching assistant (primarily graduate students)
- Original course website not available anymore, related website [here](#)

Stochastic Adaptive Control, *DTU*, Copenhagen, Denmark. 2018

- Content: A course focusing on creating adaptive control algorithms that manage uncertainty and fluctuations from stochastic external disturbances, by combining system identification methods and optimal control of stochastic systems
- Role: Teaching assistant (primarily graduate students)
- [Course website](#) (continued from the previous professor)

Interests /
personal

Technology trends, applied technology
Watersports, wintersports, music, dancing
Interested in traveling (also for work)