SDU

DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE

DEPARTMENT OF MATHEMATICS AND COMUPTER SCIENCE'S CONTRIBUTION TO FULFILLING THE

UN SUSTAINABLE DEVELOPMENT GOALS

IMADA's work on mathematics and statistics lays the foundation for understanding the financial systems.

For instance, we have expertise on modeling stochastic differential equations, which are fundamental to understanding temporal processes that have a strong random component such as financial systems.

A better understanding of the financial systems is essential to better understand the market fluctuations that sometimes spiral out of control leaving millions unemployed and in poverty.

Food bank organisations for food redistributions even in developed countries struggle to improve their operations and efficiency. IMADA contribute to develop technologies enabling more efficient operations such as:

- Building apps to help collect and deliver donated food.
- The apps use optimisation algorithms to route the trucks and fair division algorithms to allocate the donated food to different charities.

3 GOOD HEALTH AND WELL-BEING

Contributions coming from mathematics and statistics are of utmost importance in many health-related matters. E.g., we apply different methods:

- Modelling disease dynamics, for example, using renormalization group approaches to investigate the spread of Covid-19.
- Combining stochastic population dynamics models with epidemiological models to predict the impact of Covid-19 in various fields.

Furthermore, IMADA's research on algorithmic cheminformatics involves large and complex networks of chemical reactions and answers important questions and challenges in research, industry, society and help answering fundamental health related questions. Examples are:

- Understanding the regulation of metabolic networks in humans.
- Planning and optimizing chemical synthesis in industry and research labs.
- Modeling the fragmentation of molecular ions inside mass spectrometers.
- Developing personalized medicine.
- Probing hypotheses of the origins of life.

3 GOOD HEALTH AND WELL-BEING

The Center for Quantum Mathematics has undertaken an enormous endeavour to understand our world and the universe on a quantum level. When mathematically proven knowledge is achieved to unify the relativity theory of Albert Einstein with the non-relative subatomic world, we will have the tools to revolutionize our technologies and make 'quantum leaps' e.g., within ongoing research on protein and RNA folding and with resent with focus on topological quantum computing, which offers a great potential for enhancing the computational power with focus on modeling many macro-molecular biological processes.

IMADA contributes by developing AI technologies to improve the well-being of people and the involvement of citizens around health issues. For example, we are currently engaged in developing an app for a local municipality that aims at alleviating the anxiety of people with dementia and their caregivers when situations of wandering and getting lost arise. The app will be able to:

- Automatically detect and make it possible to activate the nearest volunteers to provide immediate help
- Match volunteers and people with dementia for participating together to social activities.

Project example: IMADA participates in FeatureCloud that a novel artificial intelligence (AI) platform, based on a groundbreaking new cloud infrastructure to integrate local AI globally without the need for any transfer of primary medical data – totally anonymous by default.

IMADA delivers quality education everyday, with more than 700 enrolled and 90+ masters and bachelor students graduating every year. IMADA partakes in various outreach activities at high schools where IMADA students engage with local and regional high schools. IMADA also organises further education training in cybersecurity to lift the competence level of IT professionals and companies, with particular focus on supporting SMEs.

IMADA develops tools to optimize the administration of educations. Such tools are able to:

- Schedule courses while maximizing the possibilities for student attendance.
- Allocate students to projects in a resource optimal, fair and effective way.
- Schedule exams while maximizing the time available for preparation between exams.
- Allocate instructors to courses matching preferences
- Allocate classrooms.
- Make long term plans about the needs for infrastructure.

ACTIVITY EXAMPLE: IMADA has been co-organising the Danish Championship of Cybersecurity aimed at 15–25-year-olds including training sessions with 300+ registered high school students.

Building research-based knowledge about quality in STEM education is a central focus at IMADA. A guiding value is that children, young people and life-long learners have the right to continuously build research-based knowledge about their world.

Several departmental, cross-departmental and cross-institutional research initiatives advance learning about and engagement with nature, science and technology.

IMADA hosts Laboratory for Coherent Education and Learning (LSUL), which is a strategic collaboration in research, innovation and education between University of Southern Denmark's Faculty of Natural Science, University College Lillebaelt and University College South Denmark. It brings together students, researchers and practitioners in STEM (Science, Technology, Engineering and Mathematics) education.

LSUL also provides students and teachers tools and skills for identification of questions and concrete real-life problems. Societal challenges e.g., energy efficiency, resource usage analyses and the environment are addressed through inter- and trans-disciplinary education.

IMADA is fully committed to diversity and inclusion with respect to race, national origin, gender, veterans, individuals with diverse abilities and LGBTQ+. As part of the university's engagement to contribute to the UN Sustainable Development Goals it works strategically with Gender Equality.

IMADA actively participates in this work through the university's five-person Gender Equality Team working with systemic changes and gender statistics in close cooperation with the faculties and units, including the central Gender Equality Committee and the local Gender Equality Committees.

INITIATIVES: IMADA actively coordinates and participates in "IT Camp for Piger" aiming at increasing the uptake of women in IT-educations at university level. It is part of the larger collaboration amongst universities (Aalborg University and Aarhus University) in West Denmark (IT-West).

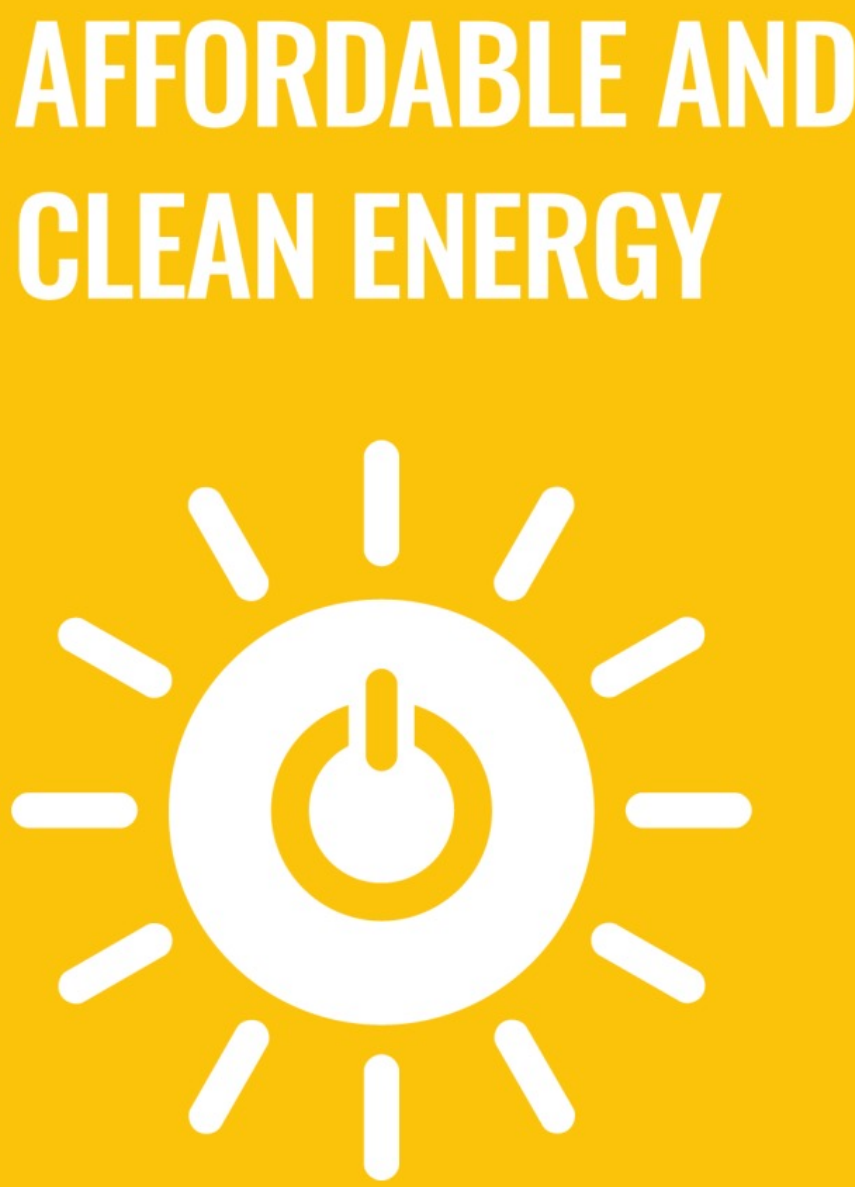
IMADA's research has a wide application within affordable and clean energy.

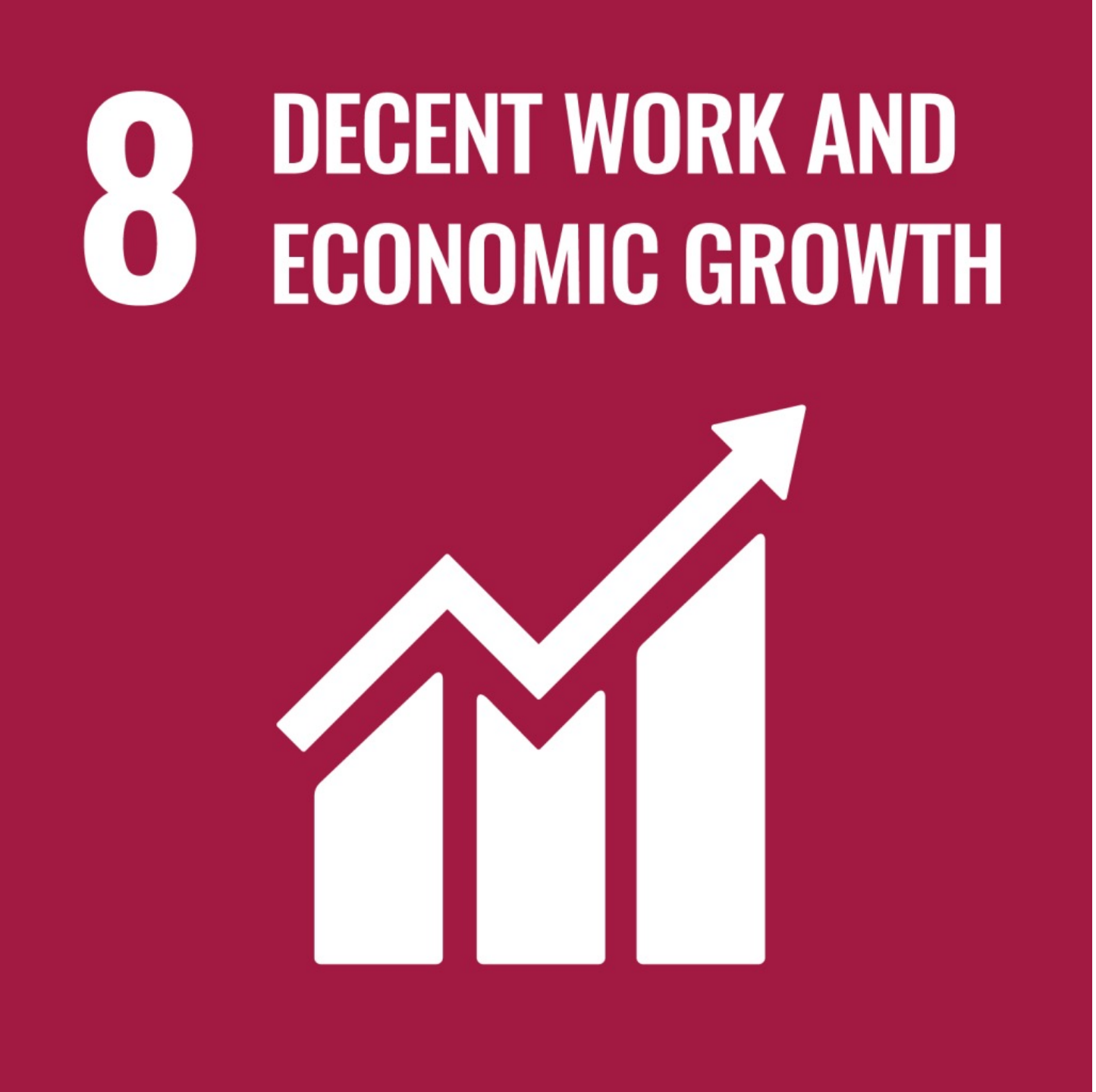
Our computation group support innovation by means of state-of-the-art modeling methods for aerodynamics applications.

IMADA's research contribute to plan energy production with strong competences in solving various forms of optimisation problems and resilient network design e.g.:

- A common planning problem to solve in the energy production is the unit commitment with co-generating plants, that makes sure that the electricity and heating that have been agreed to be sold on hourly basis are produced in the cheapest possible way, where price is a proxy for clean.
- Power companies have to optimize the inventory of fuels such as biomass.
- On the side distribution side, companies owning the electricity net must monitor and secure the bottlenecks of their infrastructure.

Project example: The project Drones4energy aims to build a collaborative, autonomous, and continuously operating drone system that will be offered to powerline operators to inspect the power grid accurately, frequently, and autonomously.





IMADA works together with a number of local companies to address recurring problems related to how to operate a business and plan work. Examples are:

- Different tasks and jobs must be carried out by workers who have the right skills while satisfying the working agreements for work conditions and taking into account the location and the movements of the workers involved.
- Workforce planning is an integral task that all medium and large size companies have to deal with to operate. This is central in time management and important for the well-being of workers, the quality of the service provided and the resource utilization by the company or organization.

IMADA's contribution to SDG 9 on industry, innovation and infrastructure are manyfold.

- The work on mathematics and statistics support innovation by means of state-of-the-art modeling methods for aerospace applications also supported by work done at the High Performance Computing (HPC) facilities at IMADA. The HPC facility based at the SDU eScience Center provides one of the largest cloud and super computing infrastructures in Northern Europe with numerous types of application relevant for industry and innovation. In 2020 IMADA was selected two new national HPC facilities especially focusing on making HPC widely accessible to researchers and industry.
- The work done in algorithmic cheminformatics is highly relevant for various types of industry, research labs and helps accelerate findings in many types of different industries.
- The Center for Quantum Mathematics focus on topological quantum computing, which offers a great potential for enhancing the computational power with focus on modeling in relation to robot and drone control.

- IMADA is a leading Danish institute in cybersecurity, employing researchers that have already impacted both theory and best practices in the field. This includes developing new programming tools and IT infrastructure that make it easier to code secure software, including privacy awareness and resilience to outsider attacks.

Project example: IMADA has amongst others participated in the project Assessment on the Status of CyberSecurity in Denmark (ACSD) that aims to study and report on the existing cybersecurity and privacy protection practices used in large Danish companies and SMEs, identifying the most important challenges the developers in Denmark face in developing secure and privacy-preserving solutions, and providing guidelines for securing critical infrastructures.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

11 SUSTAINABLE CITIES AND COMMUNITIES

IMADA develops tools to optimize the bus line network improving service for customers and reducing CO2-emissions for the bus companies.

Moreover, we analyse traffic data to detect anomalies and correlations between different parts of the road network and communicate them promptly such that actions can be taken.

We optimise:

- Vehicle routing in services and delivery of goods
- Budgets for building maintenance
- Reduce CO2-emissions of flights by optimising their routes.

The IMADA group working on statistical theory and its application are fundamental to SDG 13. For example:

- We work on the theory and modeling of extreme value statistics to understand extreme events such as those we are witnessing with climate change.
- The Center for Quantum Mathematics focus on topological quantum computing, which offers a great potential for enhancing the computational power with focus on modeling in relation to prediction of climate changes.

IMADA is working in collaboration with the Interdisciplinary Center on Population Dynamics (CPop) and the international non-profit Species360 to understand the demography of marine mammals in captivity and in the wild.

Demographic rates, these are survival and reproduction, are the fundamental building blocks to understand the dynamics of populations in different environments.

Due to the difficulties to study animals in aquatic environments, there is an unprecedented lack of demographic information for these species.

In IMADA, we are using novel statistical methods we have developed, to explore these demographic rates for animals in zoos and aquariums, and how these can help inform and predict the demographic rates of species in their natural environment.

IMADA, in collaboration with the Inter-disciplinary Center on Population Dynamics (CPop) and the international non-profit Species360, is contributing to improve our understanding and our ability to counteract the current biodiversity crisis.

Specifically, we are developing novel statistical methods to understand survival and reproduction, this is the demography, of a large number of species of terrestrial animals and plants. Many of these species are of great conservation (e.g. endangered species) and commercial value (hunted species like deer).

From the results of these models, we construct predictive mathematical models, known as population dynamics models, that help us explore the chances of extinction of populations of these species under different environments. We use these models to test how alternative wildlife management strategies can improve or affect the long-term survival of these populations.